

## Costs and Benefits of Physics Research

### Background

Throughout history, societies have expended tremendous amounts of money and other resources on the accumulation of scientific knowledge. Often, at the time of expenditure, the direct value in monetary or other terms was not readily evident, so the debate always arises as to whether the costs of scientific research and related high-tech applications outweigh their benefits.

This unit contained an overview of a number of different particle accelerators. In some cases, the device, such as a mass spectrometer, is used to identify the elements contained in a substance. In other cases, such as the Conseil Européen pour la Recherche Nucléaire and Fermi National Accelerator Laboratory accelerators, the device accelerates charged particles to a speed at which not only do their own properties change, but their collisions with other particles create the formation of yet new and different particles. The high-energy collisions made possible by particle accelerators lead to new understandings of the structure of matter.

History has shown that the more society learns about the structure and behaviour of matter, the more this knowledge can be used to improve society's standard of living. On the other hand, the costs of such endeavours are not all monetary. Often related to research and development are side effects that affect the environment and the health and freedoms of a society.

### Challenge

Build a class consensus on the costs and benefits of continuing public support for using particle accelerators in research and development in particular, and for physics research in general.



The U.S. Department of Energy's Fermi National Accelerator Laboratory.

### Plan and Present

- A. As a class, research and compile a list of particle accelerators that are currently in use, either for pure scientific research or for a particular technological application. Identify a select list of accelerators for further study. Divide the class into groups, assigning one accelerator to each group. Each group is to write a report on the accelerator's function, its associated costs, and its potential benefits. While developing this report, in preparation for the class debate described below, class members should decide on which side of the debate they want to participate.
- B. Set up a class debate on the costs and benefits to society of the public funding of research using particle accelerators in particular, and on physics research in general.

## Action Plan

1. Establish an evaluation method by preparing
  - a class rubric for evaluating individual group reports
  - a rubric for evaluating the class debate
2. Establish groups and then
  - as a class, brainstorm and conduct preliminary research into the types of particle accelerators currently in use
  - establish small working groups to investigate a representative number of particle accelerators
3. For the assigned accelerator, each small group will gather data on
  - the location and size of the accelerator
  - the physics principles about which the accelerator is designed to further knowledge
  - the monetary cost of building and operating the accelerator
  - the source of its funding
  - the type of particle accelerated
  - the final energy of the particle
  - the type of research that can be accomplished only by using these high-energy particles
  - any monetary return (profit) from applications of the accelerator
  - possible future (direct or indirect) benefits derived from the knowledge gained as a result of the research made possible by use of the accelerator
  - the environmental and societal impact of the use of the accelerator or of the knowledge gained
4. Prepare a report that summarizes the information gathered by the group.
5. Delegate responsibilities for publishing the report.

## ASSESSMENT

### After you complete this project

- assess the clarity of your report in explaining the costs and benefits of particle accelerators for research and development
- assess the success of your team in convincing the audience of your perspective during the debate
- assess the ability of the class to come to a consensus on a rational position on the costs and benefits of physics research

6. Prepare for the debate by
  - setting up two class teams that will debate on the costs/benefits of physics research; the debating teams will include both debaters and technical advisers from each of the small working groups
  - selecting a neutral person to act as moderatorEach debating team will
  - analyze the small groups' reports to determine the costs and benefits of accelerators
  - assign roles for the debate (e.g., organizing and compiling material, preparing notes, developing arguments, serving as debaters)
  - rehearse the debate
7. Publish and present the small group reports.
8. Conduct a class debate.

## Evaluate

1. Small group publications and class debate: Use the rubric prepared in step 1 of the Action Plan to evaluate the publications and class debate.
2. After the debate, through class discussion, attempt to establish a class position on the costs and benefits of the public funding of particle accelerators, and of science funding in general.